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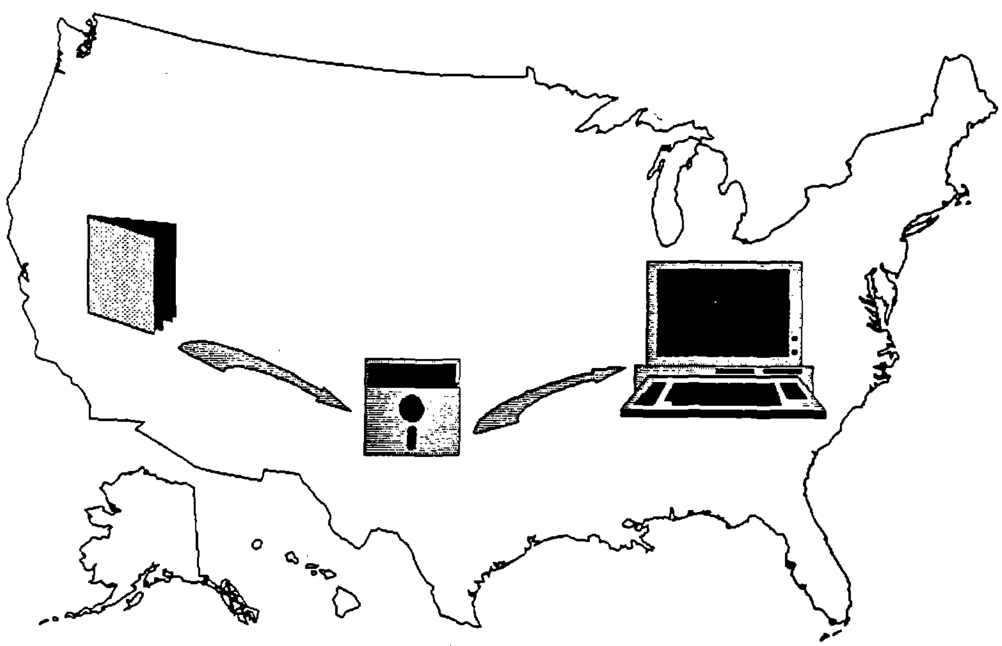
EPA

National Radon Database

Volume 1: State/EPA Residential Radon Survey



PB93-134761

NATIONAL RADON DATABASE DOCUMENTATION
Volume 1

The EPA/State Residential Radon Surveys: Year 1

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1. Introduction

The National Radon Database has been developed by the U.S. Environmental Protection Agency (EPA) to distribute information collected in two recently completed radon surveys:

1. The EPA/State Residential Radon Surveys, Years 1 to 6; and
2. The National Residential Radon Survey.

The State Residential Radon Surveys were conducted in 42 states and 6 Indian lands to characterize the state-wide distribution of radon screening measurements in the lowest livable area of owner-occupied homes. The National Residential Radon Survey was designed to provide an estimate of the national frequency distribution of annual average radon concentrations in occupied residences. Data and documentation for each survey are available through the National Technical Information Service (NTIS).

1.1 GOALS OF THE EPA/STATE RESIDENTIAL RADON SURVEYS

These surveys are statistically valid at the state level and regional levels within each state. The results represent screening measurements and should not be used to estimate annual averages or health risks. Although states and portions of states have been characterized with high or low indoor radon results, the only way to determine the indoor radon level of an individual house is to test. EPA recommends that all homes test for elevated indoor radon levels.

In response to the growing concern about potential health risks associated with indoor radon exposure, the EPA initiated a program in 1986 to assist states in measuring radon concentrations in homes. The importance of this program was confirmed by the Indoor Radon Abatement Act of 1988, Section 305, which directed the EPA to provide technical assistance to the States in assessing radon concentrations in homes. Through this program, the EPA provided assistance to states in the selection and testing of a probability-based sample of houses. Research Triangle Institute (RTI) supported EPA and the states in this effort during the six years of surveys. Assistance was provided in survey design, interviewer training, sample selection, data processing, and data analysis. In addition, the Agency provided the charcoal canisters used in the surveys and also provided all laboratory analysis.

The goals of the state radon surveys were twofold. Some measure of the distribution of radon levels among residences was desired for major geographic areas within each state and for each state as a whole. In addition, it was desired that each state survey would be able to identify areas of potentially high residential radon concentrations ("hot spots") in the state, enabling the state to focus its attention on areas where indoor radon concentrations might pose a greater health threat.

To ensure the discovery of elevated radon concentrations within a home, the charcoal canisters were exposed under closed-house conditions during the winter and were placed on the lowest livable level. Thus, the estimates of indoor radon concentration provided by the surveys reflect a worst-case scenario and maximize the likelihood of identifying residences with high radon concentrations. The screening measurement provides a measurement of the maximum concentration to which occupants may be exposed. A screening measurement also provides a basis for determining whether additional measurements are needed for making a mitigation decision. Data from these state surveys should not, however, be used directly in assessing health risks, because the screening measurements may overstate annual average concentrations in living areas of these homes.

Since the winter of 1986-87, the EPA has assisted 42 states in conducting surveys of indoor ^{222}Rn concentrations. The 42 states and 6 Indian lands radon surveys included in the National Radon Database were carried out during the six years of the program as listed in Table 1-1. Probability-based surveys also were conducted in six selected Indian lands during four of the six years of the program. The use of probabilities in making house selections allows the results to be extrapolated beyond the sample itself to a well-defined population of homes through the use of sampling weights, which are included in the database for all surveys except Colorado and Connecticut.[1] The sampling weights should be used as described in this documentation to replicate the population estimates presented here. In addition, sample data from state surveys conducted by Colorado and Connecticut are included in the Year 1 database. The sampling weights for these states are set to a value of 0 in the database.

A two-day deployment of open-faced charcoal canisters was used by 24 states and 3 Indian lands during the first three years of the state radon survey assistance program. During these years, a diffusion barrier charcoal canister was developed specifically to be less sensitive to the effects of humidity and air flow than the open-faced canister. Two-day deployment of barrier canisters was used by the eight states and two Indian lands in Year 4 of the program. The exposure period for the barrier canisters was increased from two days to seven days for Years 5 and 6. All devices were analyzed promptly at the EPA laboratory in Montgomery, Alabama. Estimates of the relative measurement error as a percentage of the measured concentration were provided by the laboratory and are included in the database. The performance of the charcoal canisters was monitored periodically through the use of unexposed canisters, canisters exposed to known levels of ^{222}Rn, and collocated canisters.

The database now contains data on short-term screening measurements made on the lowest livable level of over 63,000 randomly selected houses during the winter heating season. Survey results for the 42 states and 6 Indian lands are listed in Table 1-2, which

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[1] Colorado and Connecticut conducted state surveys and these data are included in the database for Year 1. Because sampling weights could not be determined for these samples, the survey results for these two states should not be extrapolated beyond the sample. The States of Delaware, Florida, New Hampshire, New Jersey, New York and Utah also have conducted their own surveys. Information concerning these state surveys is included in Appendix D.

shows for each state and Indian land the number of homes tested, the estimated number of residences in the target population, population estimates of the arithmetic mean (average) screening measurement radon concentration, and the estimated population percentage of homes with screening measurements over 4 pCi/L and over 20 pCi/L. Due to the lack of sampling weights for Colorado and Connecticut, reported results are applicable only to the sample households. Results are reported separately for the six Indian lands included in the database.

The geographical distribution of estimated mean screening-level radon concentrations is depicted in Figures 1-1 and 1-2 for the 38 states in the contiguous U.S. with probability-based survey results. These states contain 225 sub-state regions. In Figure 1-1 the regions are grouped into three categories using the estimated regional mean screening measurement: 0 to 2 pCi/L; 2 to 4 pCi/L; and greater than 4 pCi/L. In Figure 1-2, the top 60 regions with an estimated mean screening level over 4 pCi/L are displayed in three more-detailed categories: 4 to 6 pCi/L; 6 to 8 pCi/L; and greater than 8 pCi/L.

Figure 1-3 shows a map of the 10 EPA regions used to define the target population for the surveys of Indian lands. The names and addresses of the EPA regional office radon contacts are included in Appendix D.

Table 1-1 Summary of Six Years of the EPA/State Residential Radon Surveys

Year 1, 1986-87 heating season: ten states

Alabama	(AL)	Michigan	(MI)
Colorado	(CO)	Rhode Island	(RI)
Connecticut	(CT)	Tennessee	(TN)
Kansas	(KS)	Wisconsin	(WI)
Kentucky	(KY)	Wyoming	(WY)

Year 2, 1987-88 heating season: seven states and one Indian land

Arizona	(AZ)	Minnesota	(MN)
Indiana	(IN)	Missouri	(MO)
Massachusetts	(MA)	North Dakota	(ND)
Region 5 Indian Land	(R5)	Pennsylvania	(PA)

Year 3, 1988-89 heating season: eight states and two Indian lands

Alaska	(AK)	New Mexico	(NM)
Georgia	(GA)	Ohio	(OH)
Iowa	(IA)	Vermont	(VT)
Maine	(ME)	West Virginia	(WV)
Region 6 Indian Land	(R6)	Region 7 Indian Land	(R7)

Year 4, 1989-90 heating season: nine states and two Indian lands

California	(CA)	Nevada	(NV)
Hawaii	(HI)	North Carolina	(NC)
Idaho	(ID)	Oklahoma	(OK)
Louisiana	(LA)	South Carolina	(SC)
Nebraska	(NE)	Navajo Nation	(RN)
Billings, MT IHS Area	(RB)		

Year 5, 1990-91 heating season: six states and one Indian land

Arkansas	(AR)	Mississippi	(MS)
Illinois	(IL)	Texas	(TX)
Maryland	(MD)	Washington	(WA)
Eastern Cherokee Nation	(RC)		

Year 6, 1991-92 heating season: two states

Montana	(MT)	Virginia	(VA)

Table 1-2 EPA/State Residential Radon Survey Results, Years 1 to 6

State/Indian Land	# Homes Tested	Estimated # Homes in Population	Screening-Level Estimates Arithmetic Mean	Percent > 4 pCi/L	Percent > 20 pCi/L
AK	1,127	38,287	1.7	7.7	0.6
AL	1,180	565,603	1.8	6.4	0.3
AR	1,535	411,395	1.2	5.0	0.3
AZ	1,507	481,861	1.6	6.5	0.1
CA	1,885	2,232,780	1.0	2.4	0.1
CO*	1,443	1,443	5.2	41.5	2.7
CT*	1,451	1,451	2.8	18.5	0.9
GA	1,534	826,452	1.8	7.5	0.0
HI	523	67,044	0.2	0.4	0.0
IA	1,381	593,815	8.9	71.0	7.5
ID	1,266	187,124	3.3	20.3	1.1
IL	1,450	1,537,325	2.9	19.2	0.8
IN	1,914	992,634	3.7	28.5	1.5
KS	2,009	509,496	3.1	22.5	0.7
KY	879	585,655	2.7	17.1	1.5
LA	1,314	432,162	0.5	0.8	0.0
MA	1,659	1,010,301	3.4	22.7	1.3
MD	1,126	761,456	3.1	18.9	1.4
ME	839	236,917	4.1	29.9	1.9
MI	1,989	1,519,962	2.1	11.7	0.4
MN	919	966,496	4.8	45.4	1.4
MO	1,859	998,706	2.6	17.0	0.7
MS	960	352,285	0.9	2.2	0.1
MT	833	151,605	6.0	42.2	4.7
NC	1,290	1,114,747	1.4	6.7	0.3
ND	1,596	194,315	7.0	60.7	4.3
NE	2,027	310,857	5.5	53.5	1.9
NM	1,885	191,090	3.2	21.8	0.8
NV	1,562	93,004	2.0	10.2	0.8
OH	1,734	1,843,743	4.3	29.0	2.8
OK	1,637	538,309	1.1	3.3	0.0
PA	2,389	2,262,234	7.7	40.5	7.9
RI	376	165,646	3.2	20.6	1.9
SC	1,089	505,281	1.1	3.7	0.3
TN	1,773	741,551	2.7	15.8	1.3
TX	2,680	2,216,326	1.0	3.6	0.2
VA	1,156	972,708	2.3	13.9	1.2
VT	710	117,523	2.5	15.9	0.9
WA	1,935	711,965	1.7	8.8	1.3
WI	1,191	933,700	3.4	26.6	0.8
WV	1,006	324,038	2.6	15.7	0.8
WY	777	74,234	3.6	26.2	1.8
SUBTOTAL	59,395	28,773,526			
R5	934	5,328	2.9	19.7	1.3
R6	740	5,443	2.7	16.9	0.8
R7	669	8,478	5.4	34.9	2.7
RB	187	5,834	2.9	22.3	0.0
RC	594	786	0.8	1.7	0.0
RN	772	33,354	1.7	8.3	0.0
SUBTOTAL	3,896	59,223			
TOTAL	63,291				

(*) - Colorado and Connecticut results apply only to those homes tested in the survey.

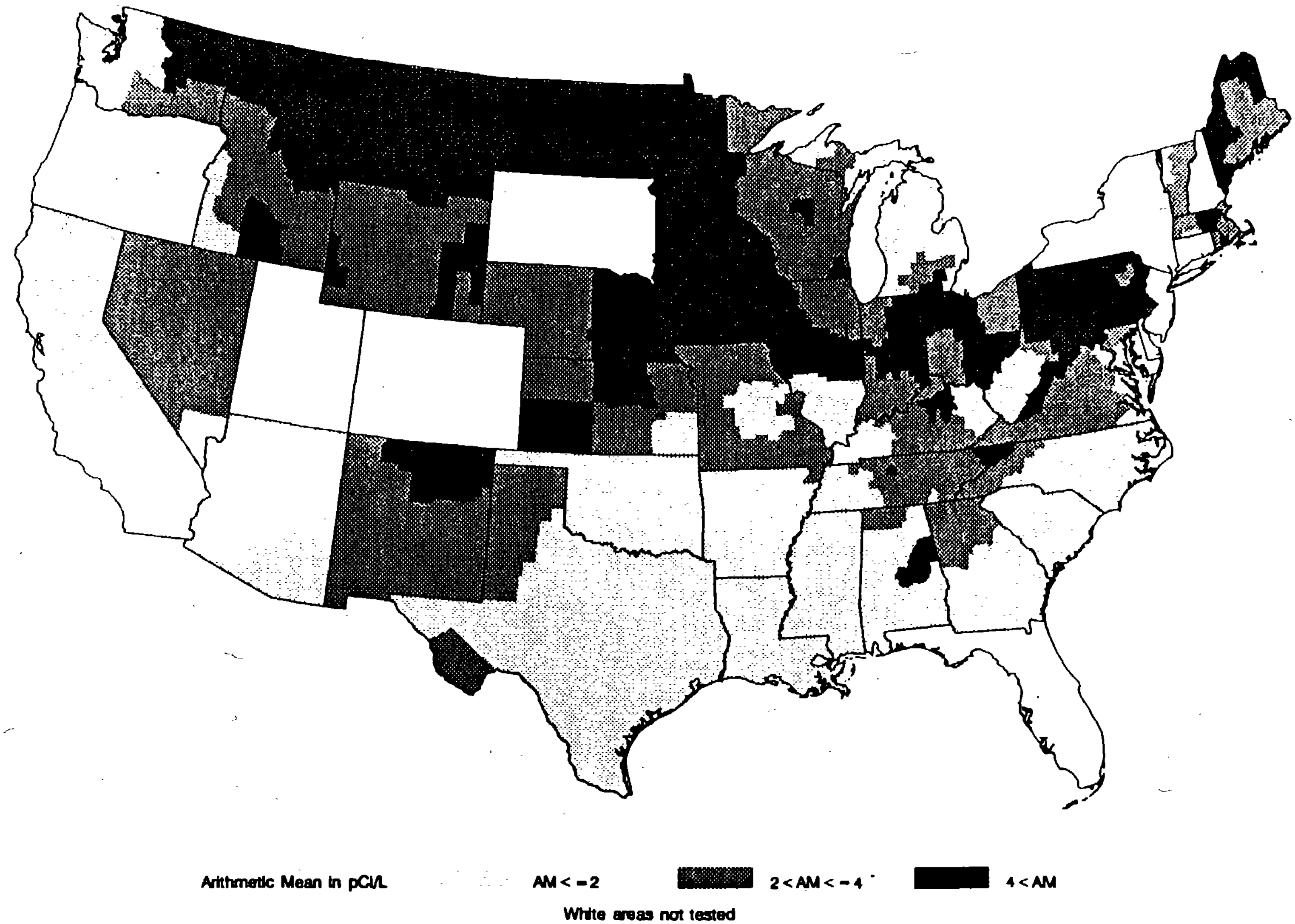

Figure 1. Distribution of Arithmetic Means of Screening Measurements in 225 Regions

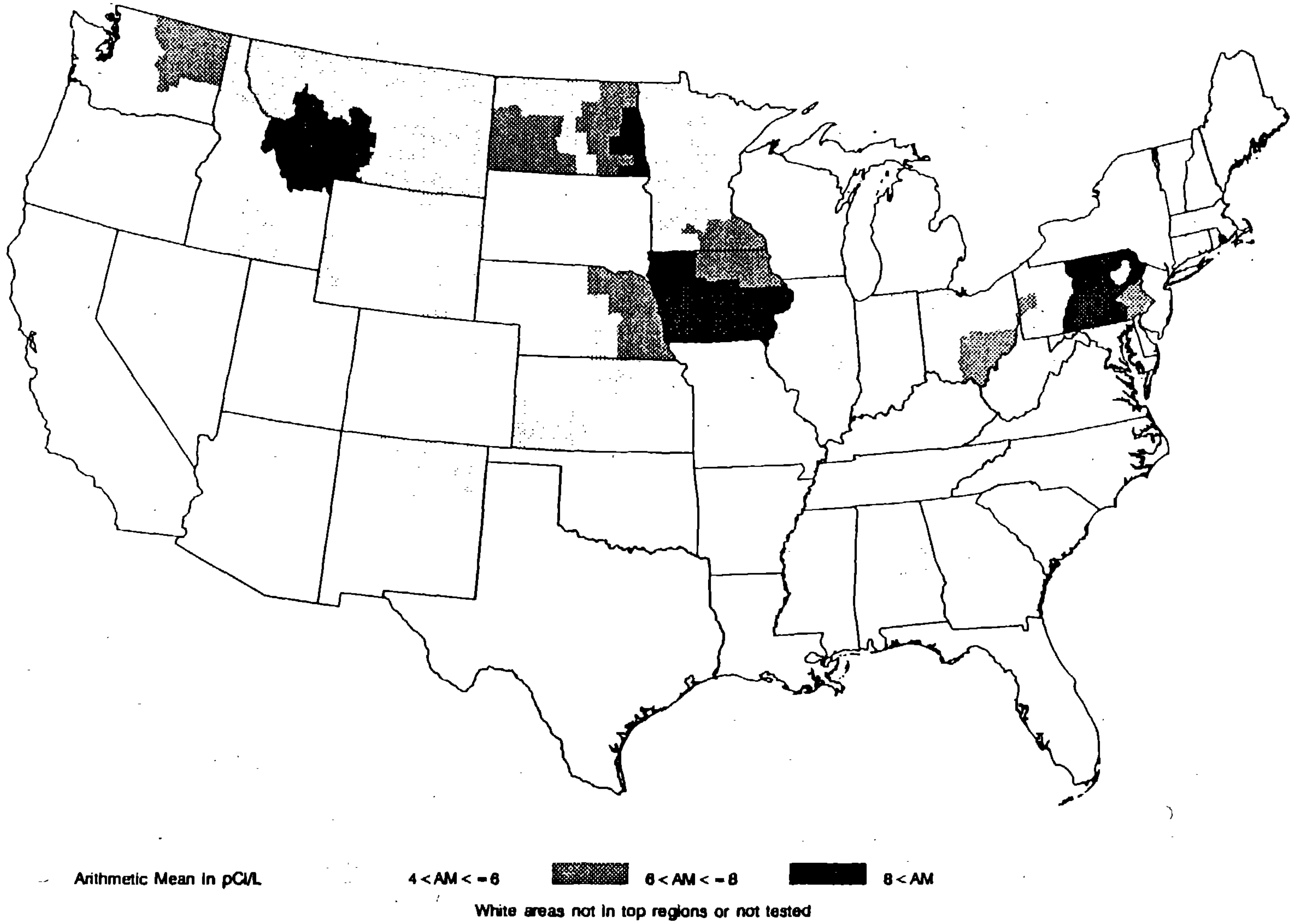

Figure 2. Distribution of Arithmetic Means of Screening Measurements in the Top 60 Regions

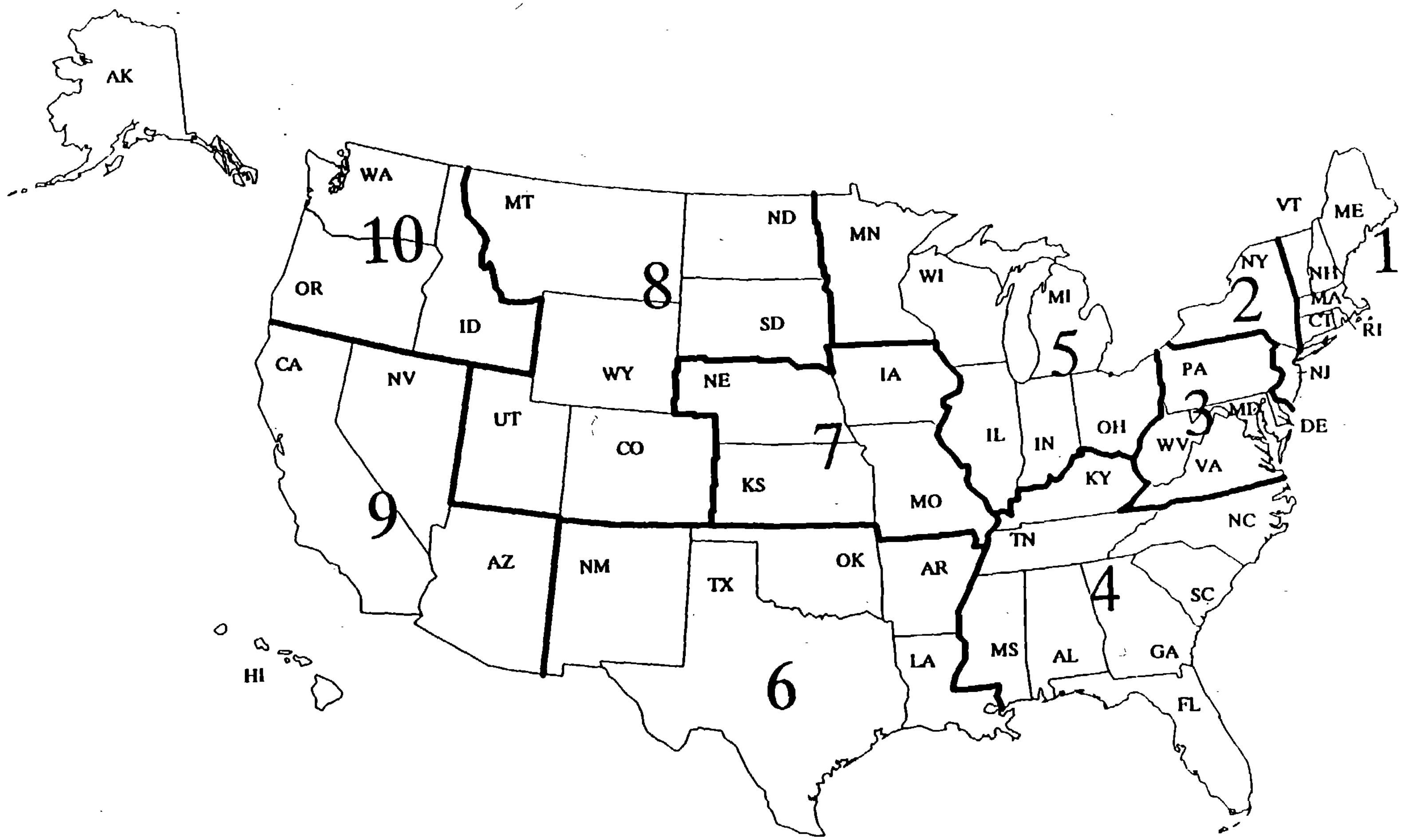

Figure 3. EPA Regions

1.2 SUMMARY OF THE YEAR 1 SURVEYS

During the winter and spring of 1986-87, the following 10 states participated with EPA in carrying out state-wide radon surveys:

Alabama	(AL)	Michigan	(MI)
Colorado	(CO)	Rhode Island	(RI)
Connecticut	(CT)	Tennessee	(TN)
Kansas	(KS)	Wisconsin	(WI)
Kentucky	(KY)	Wyoming	(WY)

For nine of the states, random samples of residences with listed telephone numbers were selected for the survey. For Connecticut, the sample was selected from a list of homes for which an energy audit had been requested. Because of the restrictive nature of the Connecticut sample, valid state and regional level statistical estimates were not possible from that survey, although estimates for the more restricted population of survey-eligible homes requesting an energy audit were possible.

Except for Connecticut, each state radon survey was based on a stratified random sample of directory-listed telephone numbers. The first step in designing a survey for a state was to partition the state into three or more geologic regions on the basis of expected radon levels. These geologic groupings were then used as strata for sample selection purposes. A cooperative effort between the State, EPA, and the U.S. Geological Survey geologists resulted in the ranking of each of these geologic regions, according to the geologists' predictions of the number of homes with high radon concentrations that would likely be found in those areas. This permitted some oversampling of homes in higher radon areas. For convenience in selecting the sample of telephone numbers, county boundaries were used to delineate the geologic regions.

The homes to receive measurements were selected as follows. First, a probability sample of residential telephone numbers was selected from a sampling frame constructed from the telephone directories for all communities in the state, sampling numbers in higher radon areas at greater rates. After the sample was selected, it was partitioned into sample waves, each consisting of a random subsample of 50 telephone numbers. The sequentially numbered waves were implemented in numerical order, permitting the generation of statistical estimates, even if the entire sample was not used.

Starting with the first wave and proceeding sequentially from wave to wave, telephone calls were made to the sample residential telephone numbers. The interviewer first screened for survey eligibility, which required that the dwelling have a floor on or below grade level and that it be owner-occupied. Once survey eligibility was established, the owner-occupant was requested to participate in the survey. Descriptive material about radon and about the survey was provided either before or after solicitation of cooperation. Those agreeing to participate were provided with a canister and instructions for its use, either by mail or in person. Participants, after exposing the canister for 48 hours, sent it, together with a short questionnaire describing where and when the readings were taken, to the EPA Laboratory in Alabama.

The state radon screening survey results are statistically valid at the state and sub-state regional level. The assignment of counties to regions within each state is detailed in Table C-1 of Appendix C. The number of radon detectors (charcoal canisters) also is shown for each county in this table. Table 1-3 contains population estimates for selected parameters of the regional and state-wide radon distribution. These estimates were obtained using the appropriate sampling weights, as described in Section 3.3. The table contains estimates of the mean (average) screening measurement, the median, the geometric mean, the 75th and 90th percentiles, and the percent of houses over 4 pCi/L and over 20 pCi/L.

Table 1-3 Parameter Estimates from the Distribution of Indoor Radon Screening Measurements in Year 1 Surveys, by State and Region (1986-87)

	Number Houses Tested	Est. No. Houses in Population	Arith. Mean pCi/L	Geo. Mean pCi/L	Median pCi/L	75th Percentile pCi/L	90th Percentile pCi/L	% Houses > 4 pCi/L	% Houses > 20 pCi/L
					Alabama				
State	1,180	565,603	1.8	0.8	0.8	1.5	2.9	6.4	0.3
Region 1	153	50,505	3.0	1.3	1.3	2.3	5.6	14.8	0.6
Region 2	119	36,211	3.5	2.1	1.9	4.0	7.2	25.1	1.7
Region 3	163	61,811	1.2	0.7	0.7	1.3	2.6	3.5	0.0
Region 4	118	49,392	1.1	0.8	0.8	1.3	2.2	3.1	0.0
Region 5	105	111,685	1.6	1.0	0.9	1.8	3.1	8.8	0.0
Region 6	156	61,786	4.4	1.0	1.1	1.6	3.2	7.3	1.7
Region 7	178	97,456	0.7	0.4	0.5	0.8	1.2	1.5	0.0
Region 8	188	96,757	0.8	0.6	0.7	1.1	1.9	0.3	0.0
					Colorado				
State	1,443	1,443	5.2	3.2	3.4	5.9	10.1	41.5	2.7
					Connecticut				
State	1,451	1,451	2.8	1.5	1.6	3.1	6.0	18.5	0.9
					Kansas				
State	2,009	509,496	3.1	1.9	2.0	3.8	6.6	22.5	0.7
Region 1	167	26,467	4.0	3.3	3.4	5.2	7.4	41.2	0.0
Region 2	190	33,043	4.4	3.2	3.1	5.4	8.3	39.8	1.1
Region 3	195	56,024	4.8	3.1	3.1	6.1	10.4	38.9	3.0
Region 4	446	143,237	2.3	1.6	1.7	2.9	4.4	12.1	0.2
Region 5	774	199,411	3.3	2.1	2.2	4.0	6.6	24.8	0.7
Region 6	237	51,313	1.1	0.6	0.6	1.3	2.6	3.4	0.0
					Kentucky				
State	879	585,655	2.7	1.3	1.2	2.6	6.5	17.1	1.5
Region 1	168	106,070	1.1	0.7	0.8	1.3	1.8	2.2	0.0
Region 2	153	94,486	3.6	1.6	1.4	3.1	8.4	21.7	4.0
Region 3	207	170,523	2.8	1.5	1.3	2.7	7.7	20.7	1.3
Region 4	143	81,563	4.5	2.4	2.6	5.7	10.6	34.5	1.9
Region 5	102	64,777	2.4	1.3	1.2	2.6	4.4	14.9	2.1
Region 6	106	68,235	1.5	1.0	1.0	1.8	2.9	6.2	0.0
					Michigan				
State	1,989	1,519,962	2.1	1.3	1.3	2.4	4.4	11.7	0.4
Region 1	493	393,251	3.1	2.0	2.1	3.9	6.4	24.1	0.5
Region 2	142	68,352	5.9	3.4	3.7	6.6	11.8	44.7	4.3
Region 3	139	13,467	3.3	1.5	1.4	2.4	4.5	11.7	1.4
Region 4	1,215	1,044,892	1.5	1.1	1.1	1.8	2.8	4.8	0.0

Table 1-3 Parameter Estimates from the Distribution of Indoor Radon Screening Measurements in Year 1 Surveys, by State and Region (1986-87) (Continued)

	Number Houses Tested	Est. No. Houses in Population	Arith. Mean pCi/L	Geo. Mean pCi/L	Median pCi/L	75th Percentile pCi/L	90th Percentile pCi/L	% Houses > 4 pCi/L	% Houses > 20 pCi/L
					Rhode Island				
State	376	165,646	3.2	1.9	1.8	3.3	6.6	20.6	1.9
					Tennessee				
State	1,773	741,551	2.7	1.4	1.3	2.8	5.1	15.8	1.3
Region 1	144	106,248	1.0	0.8	0.8	1.3	2.0	0.7	0.0
Region 2	132	89,484	1.0	0.7	0.7	1.2	1.8	2.4	0.0
Region 3	263	94,827	2.4	1.4	1.3	2.9	4.9	17.4	0.5
Region 4	245	72,621	5.1	2.3	2.0	4.7	12.9	30.0	5.4
Region 5	160	58,609	2.7	1.6	1.5	3.2	5.7	22.7	0.0
Region 6	103	45,395	2.7	1.3	1.3	2.4	3.9	9.7	1.6
Region 7	120	46,151	1.6	1.0	1.1	1.9	3.4	6.6	0.0
Region 8	121	46,730	3.3	1.6	1.5	3.1	5.2	20.8	0.8
Region 9	131	50,646	2.7	1.7	1.9	3.3	4.8	18.2	0.8
Region 10	154	59,549	4.0	2.1	2.4	4.0	8.1	25.1	2.5
Region 11	200	71,290	4.3	2.3	2.2	4.7	8.7	29.6	3.3
					Wisconsin				
State	1,191	933,700	3.4	2.2	2.3	4.2	6.9	26.6	0.8
Region 1	101	26,774	4.8	2.9	2.9	5.8	9.1	34.9	2.1
Region 2	120	29,534	3.7	2.1	2.5	5.2	7.5	30.9	1.7
Region 3	105	19,937	2.6	1.5	1.4	3.0	5.0	20.5	0.6
Region 4	135	111,554	3.0	1.9	1.9	3.6	6.9	21.1	0.7
Region 5	113	93,105	2.8	2.0	2.1	3.3	5.0	14.4	0.0
Region 6	124	142,322	3.1	2.1	2.4	4.2	5.6	27.5	0.0
Region 7	118	133,950	4.5	2.9	3.8	5.5	7.9	44.3	1.6
Region 8	110	124,827	2.9	1.7	1.8	3.2	4.8	15.9	1.8
Region 9	146	168,282	4.0	2.6	2.6	4.7	6.3	31.8	0.7
Region 10	119	83,415	3.0	1.7	1.8	3.4	7.0	20.3	0.4
					Wyoming				
State	777	74,234	3.6	2.2	2.3	4.2	7.1	26.2	1.8
Region 1	202	18,992	2.5	1.7	1.7	3.1	5.1	12.6	1.0
Region 2	215	24,576	3.0	2.0	2.0	3.8	5.2	22.1	1.6
Region 3	117	10,163	3.8	2.4	2.3	4.0	7.2	25.5	1.7
Region 4	108	9,335	4.6	2.9	3.1	5.2	7.4	35.9	2.9
Region 5	135	11,168	5.4	3.4	4.1	6.4	10.8	51.0	2.9

2. The Sample Design

2.1 THE OVERALL SAMPLING PLAN

The sampling plan for the state radon surveys called for the selection of probability samples of residences in each state. A probability sample is one in which every element in the population has a known positive chance of selection. Probability sampling permits the extrapolation of survey results to the entire population and, in addition, permits the calculation of measures of precision for the estimates. Because one of the goals of each state radon survey was the generation of estimates of distributions of residential radon levels for the state as a whole and for the major geographic areas within the state, use of probability sampling was imperative. Probability-based surveys were also necessary to validly compare results from one state with results from other.

2.2 POPULATION DEFINITION AND SAMPLING FRAMES

The target population for the surveys in nine of the ten states (the exception being Connecticut) consisted of owner-occupied homes with permanent foundations and at least one floor at or below ground level and with a telephone number published in the latest directory. The statistical estimates generated from the survey data apply to this population of residences in the state.

In reality, the totality of occupied residences in the state constituted the population of interest. However, as is often the case in survey research, it was not deemed feasible to survey this population, for several reasons. First, it was considered inadvisable from a legal perspective to include rental dwellings without first obtaining the permission of the owner. While procedures could be devised to obtain such permission, the cost in doing so both in dollars and in delay in the survey schedule was deemed impractical. Second, homes that had no floor on or below ground level were excluded from the survey target population. Although these homes are no doubt usually rental apartment units, the category would include some owner-occupied condominiums. These were excluded from the target population because radon levels on upper floors were expected to be low, and it was felt that the focus of the survey should be on residences that were potentially at risk. Third, the survey target population was restricted to homes with listed telephone numbers, basically because of time and cost considerations. Sampling of homes without regard to the existence a telephone would call for an area probability procedure, which required on-site staff for both listing and data collection and is both expensive and time consuming. The telephone survey approach was used because it offered a more economically feasible alternative. Telephone surveys can be implemented using a relatively small staff working in a central location, and can be carried out on short notice and within a restricted time schedule.

Two types of samples are commonly used for telephone surveys, random digit dialing samples, for which every possible telephone number is given a positive chance of being selected into the sample, and telephone directory samples, for which only listed telephone numbers are given a chance of selection. Each state was given the choice of these two telephone survey methods, and each chose the procedure calling for the selection of listed telephone numbers. There were two major incentives for making this choice. First, the labor involved in telephoning is much less using listed telephone numbers that it is using random digit dialing because the vast majority of listed numbers will be working residential numbers, as compared to only about 20 percent for the random digit dialing technique. Second, names and addresses are available for directory-selected addresses making possible a mailing of material describing the health risks associated with radon exposure and describing the survey. This second reason was an important consideration for those states wishing to do a mailing prior to the telephone contact.

There were two organizations that constructed files of listed telephone numbers, Survey Sampling and Donnelley Marketing. The sample for Tennessee was selected from the former company's file and samples for the other eight states were selected from the latter company's files. While both organizations had comparable sampling frames, Survey Sampling was more restrictive in the selection procedures that they were willing to implement. When it became evident that Survey Sampling had not precisely followed the sample selection procedures that had been provided and could not adapt their programs to use the procedures, Donnelley Marketing was selected.

The State of Connecticut carried out its own sample design and selection using as a sampling frame a list of homes for which an energy audit had been requested. Because the purpose of this report is to document the procedures implemented for state radon surveys, no further information is provided about the sampling procedures for this state.

2.3 STRATIFICATION AND SAMPLE ALLOCATION

In order to improve the precision of the survey estimates the sampling frame was stratified prior to sample selection. To the extent that the variable(s) used for stratification are correlated with the variable being estimated, the sampling error of the survey estimates can be reduced. The major stratification variable was, therefore, the classification of counties according to the likelihood of finding high residential radon readings in them. The counties within a state were typically classified into three to five groups by the state geologist with assistance from geologists at EPA and USGS. Using the groups provided, the total number of canisters that were expected from each county was estimated, given the total sample size that was agreed upon by EPA and the state. The estimation procedure involved simply the application of a sampling rate to the 1986 Market Statistics' estimate of housing units for the county, assuming uniform eligibility and response rates across strata.

Some investigation of the effects of sampling residences in higher radon strata at higher rates than those in lower radon strata was done. Use of differential sampling rates could increase the precision of estimates of average radon level, but could also have an effect of decreasing the precision of other estimates. As a result of this investigation, the sampling rates were typically set with an approximate four-to-one ratio of the highest-to-lowest sampling rate. This provided the desired increase in precision of radon level estimates, if the classification carried out by the geologists held. If such classification failed to partition the state into groups that were different on radon level, but instead partitioned it into, for example, groups that were identical with respect to radon levels, the precision of the estimates would not be greatly decreased. The design effect (DEFF) due to unequal sample selection rates was computed for each alternative sample allocation, with the aim of keeping it under about 1.4 or 1.5. This meant that, for the design used, the error variance of characteristics that were uniformly distributed across strata would be no more than 1.4 or 1.5 times that which would have resulted from an equal probability design. (Note that an error variance 1.4 to 1.5 times as large means a sampling error only about 1.2 times as large.)

Once the basic allocation was set, some adjustments of the strata were considered. If, for example, there were some counties for which the expected number of canisters per square mile was extremely small, an alternative allocation was prepared, moving the county to a stratum with a higher sampling rate. This was done to keep large areas of the state from being covered too sparsely, and thus compromising one of our goals, which was to identify "hot spots" in the state. Additional adjustments of different sorts were carried out. For example, when a large metropolitan area was found to have a very large expected number of canisters, an alternative allocation was done, assigning it a stratum with a lower sample rate. This permitted a somewhat higher sampling rate to be used in other portions of the state improving the likelihood of discovering any "hot spots" that might exist. The alternative sample allocations, together with a description of the advantages and disadvantages of each were sent to the states. The state selected the allocation they wished to have implemented, subject to EPA's approval.

The target number of canisters to be placed, a description of the allocation that was chosen by the state, the sampling rates used in the strata, and the expected design effect for variables that are uniformly distributed across strata are presented for each state in Appendix C.

Following guidelines determined by the agreed upon allocation, the samples for the Tennessee State Radon Survey were selected from the file that were constructed by Survey Sampling. Samples for the other eight states were selected from files constructed by Donnelley Marketing. In all cases detailed instructions for ordering the file and selecting the sample were prepared. The instructions called for the ordering of telephone listings in the state by county-size rank within strata. For the states that were sampled later, the listings were further ordered by telephone number. This assured maximum geographic spread when systematic random sample selection procedures were used.

2.4 SAMPLE SELECTION PROCEDURES

In order to permit the unbiased estimation of the sampling errors of the survey estimates of radon characteristics for the state and for major geographic subparts of the state, five independent systematic random samples were selected from each stratum. To do this, RTI provided the sample size to be selected from each stratum for each of the five samples, a list of the counties that made up each stratum, and the specifications for ordering the file within each stratum. The sample selection instructions that were provided are presented in Table 2-1.

The following variables were requested for each sample selection:

1. State FIPS code,
2. County FIPS code,
3. Stratum,
4. Area code,
5. Telephone number,
6. Name,
7. Mailing address,
8. Zip code, and
9. Sample (or replicate) number (1-5).

Table 2-1 Procedures for Selecting the Sample of Telephone Numbers

1. Sort all residential telephone numbers in the state as specified.

2. Determine the number of listings of residential telephone numbers on the file for the stratum. Call this number L.

3. Identify the sample size specified for the stratum and call this number S.

4. Divide L by S to obtain the Selection Interval I.

5. Select 5 different random numbers between (and including) 0.00000001 and I.

6. Successively add I to the first random number to generate S selection numbers. Round up the S selection numbers for the stratum to identify the sample telephone numbers on the ordered list.

7. Repeat step 6 for each of the other 4 random numbers until all 5 random samples of size S have been selected.

8. When this procedure has been implemented for all strata defined for a state, the state's sample selection is complete.

2.5 PARTITIONING THE SAMPLES INTO WAVES

Estimating the exact number of sample selections that would be needed in a state survey to be able to place the desired number of canisters was very difficult. EPA did not know the exact proportion of selected numbers that would be working residential numbers, the exact proportion of residential numbers that would be associated with survey-eligible residences, or the proportion of eligible residences that would participate in the study. Another very important unknown was when the weather in the state would become so warm that the closed house requirement for canister deployment could not be met, and the survey would have to be discontinued.

There is a commonly used technique for controlling the number of survey participants in situations where there are many unknowns involved in estimating the number of sample selections needed. The procedure involves partitioning the sample into a number of random subsamples and implementing only as many of the subsamples as are needed to achieve the desired number of participants. This technique was used in all nine states.

A sample sufficiently large for any reasonable set of assumptions was selected as described above. It was then partitioned into random subsamples, or waves, of 50 telephone listings each. The waves were randomly ordered and numbered sequentially, and were activated in numerical order by the states. Because each sample wave was a random miniature version of the entire sample, no matter where a state stopped they would have implemented a random sample of listed residential telephone numbers, provided only that they had completed all waves that were begun. It was therefore possible to produce statewide estimates for Michigan, for example, even though they were not able to complete the entire survey prior to the onset of warm weather in the spring of 1987.

The procedures used in processing the file and partitioning the sample into waves are described below.

1. The sample of 10-digit telephone numbers was checked for duplicates, which were eliminated, and was checked to verify that the proper number of records had been provided for each replicate in each stratum.

2. Five percent of each replicate was randomly designated to receive duplicate canisters.

3. The total number of waves, W, into which the sample was to be partitioned was determined by dividing the number of records on the file by 50.

4. The waves number 1 through W were put in random order and assigned to the first W records of the file. The wave numbers 1 through W were again placed in a random order and assigned to the second W records on the file, etc., until each record had been assigned a Wave number.

5. For most of the states, the records were ordered by wave number and a Case ID number was assigned sequentially. For states with multiple calling centers, the Case ID numbers were assigned sequentially by wave number within calling centers, if the state requested this modification.

3. Estimation Using Survey Results

3.1 CALCULATION OF SAMPLING WEIGHTS

Because most of the states used unequal probability sample designs for their state radon surveys, sampling weights that counter-balance the unequal probabilities of selection must be used in order to generate unbiased state-wide population estimates from the survey data. Sampling weights that reflect only the differential selection probabilities would be adequate if 100 percent response rates and participation rates were achieved. However, this level of response was not obtained. For the state radon surveys, some of the sample cases failed to complete a screening interview, either because they were never successfully contacted or because they refused to provide the screening information. Whether or not they were in fact eligible was, therefore, never determined. For other cases the screening information was provided, and the housing unit was determined to be eligible for the survey, but a canister reading was not successfully linked to the case. There are numerous reasons why this might have occurred.

The canister may not have been read, because it was never deployed; it may have been deployed but never returned; or it may have been returned but not received in time to be included in the analysis. In addition, clerical or keying errors associated with matching criteria could have prevented matching canister readings with the proper cases. In order to compensate for the missing information, a weighting class adjustment was used. This procedure increased the sampling weights of participants to compensate for the missing information from nonparticipants. The steps used in calculating sampling weights and adjustments are described below.

The first step in calculating the sampling weight was determined from the information provided by Donnelley Market Services (or by Survey Sampling for Tennessee.) For each stratum in the sample, we were provided with the number of listings from which the sample was selected. RTI had specified the number of selections that should be made.

Using this information the first component of the sampling weight was computed for each stratum, and used for all selections from that stratum. For any stratum h the first sampling weight component was calculated as

$$W'_h = N_h / [(5)(n_h)], \tag{1}$$

because 5 samples of size n_h were selected from N_h listings in stratum h.

As was described in Chapter 2, each state's sample was randomly partitioned into waves of 50 listings each, each wave being in effect a probability sample of the entire sample. Although all waves were available for use in the state radon survey, not all were used. The second component of the sampling weight represented the portion of the sample waves that were included in the analysis. Any wave for which at least 40 of the 50 cases were completed was considered to have been implemented, and will be referred to as an "active" wave. Computer runs were made on the Control/Screening form file to determine which waves would be classified as "active" and included in the analysis and which would not. For each state, we then computed the sampling weight component reflecting the proportion of wave classified as active. This was merely the total number of waves of 50 listings divided by the number of waves classified as active waves, or V/v. Only cases in the v active waves were used in the remaining calculations and in the analysis.

Next an unadjusted sampling weight was calculated for every selected case in every active wave, regardless of the response or participation status of the case. This weight was merely the product of the two weight components.

$$W''_h = (W'_h)(V/v) \tag{2}$$

Next, every record in every active wave was compared to the file of canister readings and, by matching on House ID number, was classified as a participant or a nonparticipant. All active wave cases classed as participants would be used in the analysis, because they were in an active wave and had a canister reading. In order to adjust for missing canister readings for the remaining survey eligibles that did not participate, all active wave nonparticipant cases were further classified according to eligibility status. The following groups were formed for the active wave cases:

Group A: Participants (all eligible cases for which a canister reading was available)

Group B: Survey eligible nonparticipants

Group C: Nonparticipants, survey eligibility unknown. (All cases for which eligibility information was never obtained.)

Group D: Nonparticipants known to be ineligible for the survey.

These four groupings were used in calculating the adjustments for nonresponse.

Five weighting classes were formed within each stratum, each being one of the five replicates used in the sample selection. Within each weighting class an adjustment for nonresponse factor was computed in two steps as follows:

First, an estimate of the proportion of cases that were survey eligible was computed.

$$A'_{sh} = \frac{|\Sigma W''_{shi}|_A + |\Sigma W''_{shi}|_B}{|\Sigma W''_{shi}|_A + |\Sigma W''_{shi}|_B + |\Sigma W''_{shi}|_D} \qquad (3)$$

where

$|\Sigma W''_{shi}|_A$ is the sum of the unadjusted sampling weights over all participants i in the s replica in stratum h, and where subscripts B and D refer to survey eligible nonparticipants and nonparticipants known to be ineligible, respectively.

The proportion A'_{sh} was used to estimate the proportion eligible among those for whom eligibility has not been determined. This figure was needed in order to determine the nonresponse adjustment factor for each replica s within each stratum h.

$$A'_{shi} = \frac{|\Sigma W''_{shi}|_A + |\Sigma W''_{shi}|_B + A'_{sh}|\Sigma W''_{shi}|_C}{|\Sigma W''_{shi}|_A} \qquad (4)$$

where $|\Sigma W''_{shi}|_C$ is the sum of the unadjusted weights over all nonparticipants with unknown eligibility and where all other terms are as defined above.

The final sampling weight was then calculated for each sample case in every active wave as:

$$W_{shi} = (W''_{shi})(A'_{shi}), \qquad (5)$$

and the sampling weight W_{shi} was used as the sampling weight in all analysis. The sampling weights calculated by the procedure above are included in the Year 1 data file. In the following section, instructions for use of the weights are given.

3.2 ESTIMATING MEANS AND PROPORTIONS

The analytical results calculated from the survey radon measurements should reflect the sampling weights define in the previous section. Computer software was developed by Research Triangle Institute for analyzing the data collected in this complex multistage sample survey. Formulas used in the software for estimating means and proportions are shown below.

Define Y^*_r as the true mean radon level for the r^{th} region or reporting group ($r=1,...,R$). Y^*_r can be estimate as

$$Y^*_r = \frac{\sum_{h=1}^{H} \sum_{i=1}^{n_h} J_{rhi} W_{hi} Y_{hi}}{\sum_{h=1}^{H} \sum_{i=1}^{n_h} J_{rhi} W_{hi}} \tag{6}$$

where

Y_{hi}	=	observed radon measurement for the i^{th} eligible household in stratum h ($i = 1,\ldots, n_h$, $h = 1, \ldots, H$):
W_{hi}	=	sampling weight associated with Y_{hi}; and
J_{rhi}	=	| 1 if i^{th} eligible household in stratum h is in the r^{th} region, | 0 otherwise.

The estimated mean for all regions combined (i.e., the statewide estimate) is given by

$$Y^*_o = \frac{\sum_{h=1}^{H} \sum_{i=1}^{n_h} W_{hi} Y_{hi}}{\sum_{h=1}^{H} \sum_{i=1}^{n_h} W_{hi}} \tag{7}$$

Similarly, define P^*_r as the true proportion of eligible households in the r^{th} region with radon levels exceeding X pCi/l. P^*_r can be estimated as

$$P^*_r = \frac{\sum_{h=1}^{H} \sum_{i=1}^{n_h} J_{rhi} W_{hi} I_{xhi}}{\sum_{h=1}^{H} \sum_{i=1}^{n_h} J_{rhi} W_{hi}} \tag{8}$$

where W_{hi} and J_{rhi} are as previous defined and

I_{xhi} = | 1 if measurement on i^{th} eligible household in stratum h is
| greater than X pCi/l
| 0 otherwise.

The estimated proportion for all regions combined (i.e., the statewide estimate) is given by

$$P^{*}_{o} = \frac{\sum_{h=1}^{H} \sum_{i=1}^{n_h} W_{hi} \, I_{xhi}}{\sum_{n=1}^{H} \sum_{i=1}^{n_h} W_{hi}} \qquad (9)$$

4. Methodological Results

The survey methodology used during the first year of the State/EPA Radon Survey program was reviewed at four different levels :

- First, the coverage of each state survey was assessed. To do this, three different estimates were compared of the number of owner occupied single family housing units having a telephone, which was the approximate definition of the survey eligible population. For each state, the survey estimate of this population size was compared to an estimate based on the 1980 Census counts for the state and was also compared to an estimate made using current counts from the Donnelley Marketing Service files from which most of the state samples were selected.

- Second, the response rate obtained in each of the states was computed. This was simply the ratio of the estimated number participants to the estimated number of eligibles.

- Third, the Control/Screening Forms that were returned by the states were reviewed to identify the types of errors that the states made in carrying out the survey.

- Fourth, the types of problems that occurred throughout the course of all of the State Radon Surveys were assessed to determine the modifications needed in our survey procedures.

In the sections that follow each of these assessments of the State Radon Survey methodology is discussed.

4.1 COVERAGE AND RESPONSE RATES

The results of the coverage investigation are presented in Table 4-1. For each of the nine states for which we selected the State Radon Survey sample, the number of owner occupied single family housing units with a telephone was estimated using 1980 decennial census information, using Donnelley file counts and, where possible, using State Radon Survey results. In constructing these estimates the percentage of housing units that were owner occupied was available by state, but the percentage of owner occupied housing units that were single unit structures was available only for the nation as a whole. The national average, of 94 percent of all owner occupied housing being single unit structures, was therefore used in the calculations for each of the states. In addition, the nationwide estimate of 97 percent was used for the percentage of owner occupied single structure housing units having a telephone.

Column 4 of Table 4-1 shows an estimate of the approximate number of survey eligible housing units using 1980 census counts, and column 6 shows comparable estimates made from the Donnelley file counts. The ratio of the Donnelley estimate to the Census estimate, shown in column 7, varies from a low of .75 for the state of Michigan to a high of .95 for the state of Wisconsin. This ratio was calculated to get a very rough indicator of what we might have missed using the Donnelley files as sampling frames, without using a supplementary procedure for picking up otherwise survey eligible housing units not linked to a Donnelley listing.

Column 10 shows the ratio of the number of survey eligibles in each state, as estimated from the survey itself, to the estimate made directly from the Donnelley frame counts. This ratio was calculated as a measure of the loss suffered because of movers and possibly because of households being difficult to reach. Recall that the procedures selected a sample of telephone numbers and the housing units linked to those numbers, regardless of whether the address was the same as was given in the frame. Therefore, housing units of movers were picked up, but not to the degree in which they were lost. When someone moves, their telephone number is typically retired for a period of six months to a year, unless it is carried to the new home. Therefore, many movers were reached at their new home.

Intrastate movers changing telephone numbers and those moving in from another state after the cutoff date associated with that portion of the Donnelley listing were lost to us.

The ratio of survey estimated survey eligibles to Donnelley estimated survey eligibles ranged from a low of .81 for Wyoming to a high of .96 for Kentucky.

Approximate response rates are presented in column 5 of Table 4-2. These range from a low of 57 percent for Kentucky to a high of 75 percent for Wyoming. Since these numbers for these two States are in reverse order to those mentioned above on coverage, there might have been some difference in the way the two states assigned result codes representing the disposition of the screening contact with sample selections.

4.2 FORMS REVIEW

The principal difficulties encountered in processing the State Radon Survey materials were:

1. Incomplete and inconsistent results on screening forms.
2. Failure to return all screening forms for sample waves that were implemented.
3. Late receipt of forms.

Many screening forms were returned to us without a final result code assigned, with an insufficient number of telephone calls, or with inconsistent results.

In generating statistical estimates from the survey data, every sample case in every implemented sample wave must be accounted for. Each such case for which a screening form was not returned was classified as "eligibility status unknown." Sampling weight calculations included adjustments for that portion of this category of nonresponse estimated to be survey eligible and for failure of sample eligibles to participate. These adjustments were made in an attempt to reduce the possible bias caused by missing information for sample cases. However, no adjustment can eliminate the potential for such bias. This can only occur by eliminating cases for which eligibility status is unknown and eliminating nonresponse.

Table 4-3 presents some results obtained from the screening form edit. Column 1 shows the number of screening forms that were edited, regardless of whether or not they were associated with a sample wave included in the analysis. Column 2 shows the number of forms with corrections in the name or address of the sample cases. The corrections made reflect actual changes caused by a move from one address to another (with the family maintaining the old telephone number), assignment of the telephone number to a new family, or merely a correction or a supplement to the name or address information to facilitate mailing or locating the dwelling for canister placement.

Column 3 of Table 4-3 presents the number of screening forms showing an insufficient number of telephone calls made prior to assigning a final result code. A minimum of seven calls were to be made to telephone numbers yielding "busy" or"ring, no answer" result codes, and a minimum of two calls were to be made to initial refusals. When fewer calls were made, the case was classified as a "too few calls" error. This type of error was a particularly persistent problem in Alabama, Colorado and Kansas.

Table 4-1 Comparison of Estimates of Survey Eligibles

State	1980 Census: Number of Occupied Housing Units	1980 Census: Percent Owner Occupied	1980 Census: Estimated Number of Owner Occupied Single Family Housing Units with Telephones	1987-1988 Donnelley: Number of Housing Units with Telephone	1987-1988 Donnelley: Estimated Number of Owner Occupied Single Family Housing Units with Telephones	1987-1988 Donnelley: Ratio of Donnelley Estimated Eligibles to Census Estimate	State Radon Survey Estimates: Sample Sizes	State Radon Survey Estimates: Estimated Number of Survey Eligible Housing Units	State Radon Survey Estimates: Ratio of Survey Estimated Eligibles to Donnelley Estimates	State Radon Survey Estimates: Ratio of Survey Estimated Eligibles to Census Estimate
(1)	(2)	(3)	(4)*	(5)	(6)**	(6) + (4) = (7)	(8)	(9)	(9) + (6) = (10)	(9) + (4) = (11)
AL	1,342,000	70.1	858,769	1,024,419	675,031	.79	1191	570,432	.85	.66
CO	1,661,000	64.5	623,986	950,972	576,574	.92	***	***	***	***
KS	872,700	70.2	558,153	778,073	513,435	.92	***	***	***	***
KY	1,263,000	70.0	806,122	925,116	608,726	.76	880	586,142	.96	.73
MI	3,195,000	72.7	2,117,897	2,330,127	1,592,362	.75	195	1,328,698	.83	.63
RI	339,000	58.8	181,751	277,742	153,614	.84	***	***	***	***
TN	1,619,000	68.6	1,012,676	1,264,067	815,121	.80	1775	742,199	.91	.73
WI	1,652,000	68.2	1,027,292	1,519,637	974,209	.95	1197	946,606	.97	.92
WY	166,000	69.2	104,740	143,177	93,134	.89	784	75,239	.81	.72

* Assuming 94 percent of owner occupied units are 1 unit structures, (1983). Also assuming 97 percent of housing units have a telephone (1981).

** Assuming column (3) percent owner occupied and that 94 percent of these are 1 unit structures.

*** Not available at this time.

Table 4-2 Sample Sizes and Response Rates by State

State	Number of Waves Used in Analysis (1)	Sample Size Used in Analysis (2)	Number of Participants* (3)	Ratio of Sample Size to Participants (2) ÷ (3) = (4)	Approximate Response Rate* (5)
Alabama	73	3650	1180	3.1	58%
Colorado	-	-	-	-	-
Connecticut	-	-	-	-	-
Kansas	-	-	-	-	-
Kentucky	49	2450	899	2.8	57%
Michigan	11	550	191	2.0	60%
Rhode Island	-	-	-	-	-
Tennessee	81	4157	1773	2.3	73%
Wisconsin	59	2950	1191	2.5	66%
Wyoming	39	1950	777	2.5	75%

* Number of sample cases with a canister reading on file.

** (Estimated number of participants) (100) / (Estimated number of eligibles in sample used)

Table 4-3 Summary of Screening Form Coding Results by State

State	Number of Records Coded (1)	Percent With Name and/or Address Correction (2)	Number of Cases With Too Few Calls* (3)
Alabama	3704	37%	456
Colorado	2311	15%	196
Kansas	2755	16%	569
Kentucky	2698	20%	30
Michigan	1287	13%	3
Rhode Island	262	1%	-
Tennessee	4239	28%	7
Wisconsin	3200	27%	31
Wyoming	2011	27%	5

* A minimum of seven calls were to be made to numbers with such temporary result codes as "ring no answer" or "busy." A minimum of two calls were to be made to initial refusal, with the attempt at refusal conversion ideally handled by a different and more experienced interviewer.

APPENDIX A

Installation Procedures

INSTALLATION PROCEDURES

1. EXTRACTING DATA FROM THE DISKETTE

The diskette you have received contains three files:

- **DATA.FIL** - a compressed version of the screening measurement data collected in one year of the EPA/State Residential Radon surveys.
- **EXTRACT.EXE** - an executable program to extract and store the expanded version of the survey data file on your hard disk. The extract program will run on any IBM-compatible personal computer using the MS-DOS operating system, Version 2.0 or higher.
- **READ_ME.1ST** - a copy of these instructions.

To expand the compressed file onto your hard disk, place the diskette in the appropriate drive and change to this drive. (For example, type **A:** then press the Enter key.) Run the program by typing the command **EXTRACT**, then press the Enter key. The program will ask where you want to store the expanded file. Respond by entering a full DOS pathname and filename to specify the drive, directory and name for the expanded file. For example, you may enter **C:\SURVEY\FILE1.DAT**. Note that the directory to which the file will be written **(C:\SURVEY)** must already exist on your hard disk. If the file **(FILE1.DAT)** already exists on the directory, you will be asked if you want to overwrite the file. Enter **Y** or **N**, as appropriate. The expanded file will be created under the filename and directory specified.

The program will ask if you want to extract specific State/Indian lands data from the survey data file. (Note: Read the file size considerations noted below before deciding how to extract the data.) To extract all of the data in the file, enter **A**. Enter **S** to extract only a subset of the data, rather than the entire file. You may select state codes from the list as instructed by the program. Note that the codes must be entered exactly as listed. After selecting the states, enter **1** to extract the file. If you make a mistake, enter **2** to re-enter the list of codes. You may enter **3** at any time to see the list of codes again, or **0** to exit the program.

2. SIZE CONSIDERATIONS

The entire expanded file for this diskette requires approximately 1.3 Megabytes of disk space. The expanded file is a standard DOS text file, with fixed-length records, one record for each house returning useable measurements. The expanded data file contains 99 ASCII text characters on each record, followed by carriage return and linefeed characters at the end of each line of text. A description of the layout of information on each record is included in the documentation for this diskette as Appendix B. The variable names listed there are the names used in EPA's analysis of the survey data.

The expanded file may be imported into a variety of DOS application programs for display and/or analysis. Most DOS applications can import DOS text files. Analysis of the data will require the use of an application program and a computer with sufficient memory available to handle a file of the required size. This should be considered when the Extract program is run. If data for all states on the disk are extracted into a single expanded file and your computer does not have additional extended or expanded memory beyond the now standard 640 Kilobytes of DOS memory, the large size of the expanded file may cause problems in many applications.

Another consideration is the number of lines (records) in the expanded file. While Excel for Windows can accommodate over 16,000 lines of data, many spreadsheet programs have a limit of approximately 8,000 lines. The entire expanded file exceeds 8,000 lines and an error will occur when importing the file into Lotus 123, for example, although sufficient memory may be available. <u>If these size problems are a concern for your program or computer, we recommend extracting the data for each state into a separate file.</u> The resulting expanded files for each state will be much smaller and problems due to size will be avoided.

3. ACCESSING DATA IN THE EXPANDED FILE

The expanded file is sorted by county within states, so that all records for a given county are grouped together in the file. For users without access to more powerful software, selected portions of the data may be viewed and printed using any word processing program that accepts DOS text files as input. For example, in version 5.0 of Wordperfect this is accomplished by the [Control-F5, 1, 2] keystroke sequence. Select a smaller font or use the landscape page orientation to print all 99 columns of data.

To conserve disk space, the expanded file does not include blank spaces between adjacent entries on a record, so a simple printout of the file as received may difficult to read. It is also difficult to analyze the data using a word processing program. DOS spreadsheet and database application programs may be used to reformat, graph and/or analyze the data.

The expanded file may be imported into a Lotus 123 spreadsheet, for example, using the [/File, Import, Text] keystroke sequence, if sufficient memory is available. The specific variables on each record may be parsed into individual numeric and label cells using the [/Data, Parse, Format, Create] keystroke sequence to specify the columns with the desired information. Then set the Input and Output ranges from the data parse menu, followed by Go. Other spreadsheet and database packages have specific procedures for importing DOS text file specified in the user reference manual.

4. CONSIDERATIONS FOR DATA ANALYSIS

This file reports short-term screening level radon measurements, conducted in accordance with prevailing EPA protocols in effect in the year of the survey. The file contains one record for each surveyed home with a useable radon measurement collected during the survey. Some data fields may have missing entries on certain records. Although attempts were made to gather complete information on each useable radon test, it was not possible to complete all items for all surveyed homes. Missing data items are indicated by a blank data field or by a single period in the data field.

The radon concentrations were estimated using a laboratory counting procedure on the exposed charcoal canisters, with a correction made for counts due to background radiation. This correction results in negative estimates of the radon concentration in some homes. These negative numbers should be considered a result of measurement error. In reality, radon concentrations are always non-negative.

The percent error variable recorded on the data file is the percentage measurement error reported by the EPA laboratory. This 2-sigma error bound was calculated based on the expected counting errors involved in the measurement process. No percentage measurement errors were reported by the laboratory for radon activities less than about 0.50 pCi/L. In the database the percent error variable is set to 0.0 on these records. For this variable, a percent error value of 0.0 should be treated as a missing value. In reality, the percentage measurement error associated with these measurements is very large.

The two problems noted above both derive from the lack of a specified Lower Limit of Detection (LLD) for the state survey data. One solution to both problems is to use the percent error variable to define the LLD for the radon activity variable. If the percent error is 0.0 and the radon activity is 0.5 pCi/L or less, then the radon activity measurement is below the LLD for the laboratory and its actual numeric value is meaningless. Alternatively, the negative activity values may be set to a small non-negative number, such as 0.05 pCi/L. This alternative method was used to calculate the survey statistics reported in this documentation.

APPENDIX B

Record Layout for State Residential Radon Surveys

Record Layout for State Residential Radon Surveys

Variable	Position	Type	Length	Description
STATE	1-2	A	2	State Postal Abbreviation (R5, R6, R7, RB, RC, RN are Indian Nations)
STATE2	3-4	A	2	State Postal Abbreviation for Indian Land Surveys (STATE = STATE2 for all other records)
STFIPS	5-6	N	2	State FIPS Code
ZIP	7-11	A	5	Zip Code
REGION	12-13	N	2	Analysis Region Code
TYPEBLDG	14	N	1	Type of Building 0 = unknown 1 = single family 2 = multi-family 3 = business 4 = school 5 = other
FLOOR	15	N	1	Floor Level 0 = basement 1 = first floor 2 = second floor or above 9 = unknown
ROOM	16	N	1	Type of Room 0 = unknown 1 = bedroom 2 = family room 3 = living room 4 = unfinished basement 5 = office 6 = classroom 7 = other

Record Layout for State Residential Radon Surveys - continued

Variable	Position	Type	Length	Description
BASEMENT	17	A	1	Is There a Basement in the Building? blank = unknown Y = Yes N = No
WINDOOR	18	A	1	House Closed or Open During Test blank = unknown O = Open C = Closed
REP	19-20	N	2	Replicate Number
STRATUM	21-22	N	2	Stratum Number
WAVE	23-25	N	3	Wave Number
STARTTM	26-29	N	4	Start Time of Test (HHMM)
STOPTM	30-33	N	4	Stop Time of Test (HHMM)
STARTDT	34-39	N	6	Start Date of Test (MMDDYY)
STOPDT	40-45	N	6	Stop Date of Test (MMDDYY)
ACTIVITY	46-53	N	8.1	Activity (pCi/L)
PCTERR	54-61	N	8.1	Percent Error (2-sigma)
ADJWT	62-74	N	13.6	Analysis Weight
DUPFLAG	75	N	1	Duplicate Flag 0 = activity from single canister 1 = average activity from duplicate canisters
ZIPFLAG	76	N	1	Flag for Zip Code (ZIP) 0 = believed accurate 1 = questionable

Record Layout for State Residential Radon Surveys - continued

Variable	Position	Type	Length	Description
CNTYFIPS	77-79	N	3	County FIPS Code
COUNTY	80-99	A	20	County Name

APPENDIX C

Description of Sample Allocation Used for Each State

ALABAMA (01)

Allocation #3 was used.
Expected DEFF = 1.468

Stratum	Geological Classification Expected Radon Level	Canisters	Relative Sampling Rates
1	AL01 (H)	66	5.5 x
2	AL02 (M)	35	3.9 x
3	AL02 (M)	723	3.6 x
4	AL03 (L)	130	5.5 x
5	AL03 (L)	176	4.5 x
6	AL03 (L)	194	2.5 x
7	AL03 (L)	140	1.2 x
8	AL03 (L)	222	1.0 x
	Total:	1,686	

COLORADO (08)

Allocation #3 was used.
Expected DEFF = 1.86

Stratum	Geological Classification Expected Radon Level	Canisters	Relative Sampling Rates
1	C003, C004 (M,L/M)	184	29.0 x
2	C001, C002, C003, C004 (H, M/H, M,L/M)	614	13.0 x
3	C001, C003, C004 (H,M)	209	5.0 x
4	C002, C003, C004 (M/H)	304	3.7 x
5	C002, C003 (M/H,M)	480	2.5 x
6	C002, C003, C004 (M/H,M,L/M)	445	1.0 x
	Total:	2,236	

CONNECTICUT (09)

The sample for Connecticut was not designed or selected by RTI, but rather was selected by the State of Connecticut from a list of homeowners who had requested an energy audit.

KANSAS (20)

Allocation #2 was used.
Expected DEFF = 1.095

Stratum	Geological Classification Expected Radon Level	Canisters	Relative Sampling Rates
1	KS01 (H)	136	4.0 x
2	KS01 (H)	1,008	1.5 x
3	KS02 (L)	156	3.3 x
4	KS02 (L)	90	1.5 x
5	KS02 (L)	1,300	1.0 x
	Total:	2,700	

KENTUCKY (21)

Allocation #2 was used.
Expected DEFF = 1.147

Stratum	Geological Classification Expected Radon Level	Canisters	Relative Sampling Rates
1	KY01 (H)	85	2.7 x
2	KY01 (H)	591	2.0 x
3	KY01 (H)	175	1.0 x
4	KY02 (L)	168	2.7 x
5	KY02 (L)	105	1.5 x
6	KY02 (L)	275	1.0 x
	Total:	1,400	

MICHIGAN (26)

Allocation #7 was used.
Expected DEFF = 1.406

Stratum	Geological Classification Expected Radon Level	Canisters	Relative Sampling Rates
1	MI01, MI03 (H,M)	246	8.7 x
2	MI02 (M/H)	290	2.3 x
3	MI03, MI04 (M,L)	126	4.4 x
4	MI03 (M)	484	1.3 x
5	MI03 (M)	392	0.7 x
6	MI03 (M)	235	0.5 x
7	MI04 (L)	119	2.2 x
8	MI04 (L)	307	1.0 x
	Total:	2,200	

RHODE ISLAND (44)

Allocation: not stratified.
Expected DEFF = 1.00

Stratum	Geological Classification Expected Radon Level	Canisters	Relative Sampling Rates
1	RI01 (not classified)	500	1.0 x
	Total:	500	

WISCONSIN (55)

Allocation #2 was used.
Expected DEFF = 1.264

Stratum	Geological Classification Expected Radon Level	Canisters	Relative Sampling Rates
1	WI01 (H)	220	4.2 x
2	WI01, WI02 (H,M/H)	106	15.0 x
3	WI03 (M)	318	1.6 x
4	WI04 (L)	63	2.8 x
5	WI04	563	1.0 x
	Total:	1,270	

WYOMING (56)

Allocation #2 was used.
Expected DEFF = 1.286

Stratum	Geological Classification Expected Radon Level	Canisters	Relative Sampling Rates
1	WY01, WY02 (H,M)	394	4.0 x
2	WY02, WY03 (M,L)	813	2.5 x
3	WY02, WY03 (M,L)	233	1.0 x
	Total:	1,500	

Table C-1 Distribution of Canisters per County for Alabama

COUNTY	REGION	# CANISTERS
AUTAUGA	6	9
BALDWIN	7	31
BARBOUR	8	9
BIBB	4	7
BLOUNT	3	11
BULLOCK	8	6
BUTLER	8	18
CALHOUN	6	23
CHAMBERS	8	9
CHEROKEE	3	1
CHILTON	6	9
CHOCTAW	7	15
CLARKE	7	8
CLAY	6	11
CLEBURNE	6	6
COFFEE	8	18
COLBERT	1	10
CONECUH	7	14
COOSA	6	8
COVINGTON	8	16
CRENSHAW	8	13
CULLMAN	3	30
DALE	8	3
DALLAS	7	18
DE KALB	3	31
ELMORE	6	25
ESCAMBIA	7	9
ETOWAH	3	21
FAYETTE	4	7
FRANKLIN	1	8
GENEVA	8	7
GREENE	4	8
HALE	4	10
HENRY	8	8
HOUSTON	8	10
JACKSON	3	21
JEFFERSON	5	78
LAMAR	4	12
LAUDERDALE	1	44
LAWRENCE	1	9
LEE	8	20
LIMESTONE	1	35
LOWNDES	8	4
MACON	8	5
MADISON	2	119

Table C-1 Distribution of Canisters per County for Alabama (Continued)

COUNTY	REGION	# CANISTERS
MARENGO	7	11
MARION	4	10
MARSHALL	3	34
MOBILE	7	43
MONROE	7	9
MONTGOMERY	8	25
MORGAN	1	47
PERRY	4	9
PICKENS	4	11
PIKE	8	8
RANDOLPH	6	9
RUSSELL	8	9
SHELBY	5	27
ST. CLAIR	3	14
SUMTER	4	8
TALLADEGA	6	37
TALLAPOOSA	6	19
TUSCALOOSA	4	14
WALKER	4	14
WASHINGTON	7	13
WILCOX	7	7
WINSTON	4	8

Table C-1 Distribution of Canisters per County for Colorado

COUNTY	REGION	# CANISTERS
ADAMS	NA	3
ALAMOSA	NA	1
ARAPAHOE	NA	2
ARCHULETA	NA	11
BACA	NA	34
BENT	NA	16
BOULDER	NA	54
CHAFFEE	NA	7
CHEYENNE	NA	32
CLEAR CREEK	NA	0
CONEJOS	NA	0
COSTILLA	NA	1
CROWLEY	NA	18
CUSTER	NA	2
DELTA	NA	131
DENVER	NA	2
DOLORES	NA	11
DOUGLAS	NA	5
EAGLE	NA	142
EL PASO	NA	3
ELBERT	NA	2
FREMONT	NA	88
GARFIELD	NA	0
GILPIN	NA	0
GRAND	NA	23
GUNNISON	NA	34
HINSDALE	NA	0
HUERFANO	NA	13
JACKSON	NA	56
JEFFERSON	NA	1
KIOWA	NA	13
KIT CARSON	NA	18
LA PLATA	NA	1
LAKE	NA	6
LARIMER	NA	123
LAS ANIMAS	NA	2
LINCOLN	NA	90
LOGAN	NA	0
MESA	NA	114
MINERAL	NA	3
MOFFAT	NA	25
MONTEZUMA	NA	1
MONTROSE	NA	22
MORGAN	NA	0
OTERO	NA	19

Table C-1 Distribution of Canisters per County for Colorado (Continued)

COUNTY	REGION	# CANISTERS
OURAY	NA	11
PARK	NA	2
PHILLIPS	NA	0
PITKIN	NA	0
PROWERS	NA	18
PUEBLO	NA	32
RIO BLANCO	NA	36
RIO GRANDE	NA	1
ROUTT	NA	2
SAGUACHE	NA	9
SAN JUAN	NA	4
SAN MIGUEL	NA	9
SEDGWICK	NA	0
SUMMIT	NA	0
TELLER	NA	3
WASHINGTON	NA	1
WELD	NA	31
YUMA	NA	3

Table C-1 Distribution of Canisters per County for Kansas

COUNTY	REGION	# CANISTERS
ALLEN	6	20
ANDERSON	6	9
ATCHISON	5	10
BARBER	4	9
BARTON	4	24
BOURBON	6	15
BROWN	5	7
BUTLER	4	29
CHASE	4	10
CHAUTAUQUA	6	6
CHEROKEE	6	20
CHEYENNE	1	11
CLARK	2	6
CLAY	3	7
CLOUD	3	11
COFFEY	6	4
COMANCHE	2	5
COWLEY	4	29
CRAWFORD	6	46
DECATUR	1	4
DICKINSON	3	15
DONIPHAN	5	5
DOUGLAS	5	36
EDWARDS	2	4
ELK	6	3
ELLIS	1	26
ELLSWORTH	3	17
FINNEY	2	15
FORD	2	14
FRANKLIN	5	22
GEARY	3	8
GOVE	1	8
GRAHAM	1	6
GRANT	2	8
GRAY	2	5
GREELEY	2	5
GREENWOOD	6	5
HAMILTON	2	8
HARPER	4	7
HARVEY	4	13
HASKELL	2	2
HODGEMAN	2	6
JACKSON	5	8
JEFFERSON	5	10
JEWELL	3	8

Table C-1 Distribution of Canisters per County for Kansas (Continued)

COUNTY	REGION	# CANISTERS
JOHNSON	5	339
KEARNY	2	9
KINGMAN	4	7
KIOWA	2	8
LABETTE	6	17
LANE	2	3
LEAVENWORTH	5	28
LINCOLN	3	7
LINN	6	8
LOGAN	1	8
LYON	5	17
MARION	4	2
MARSHALL	5	12
MCPHERSON	4	21
MEADE	2	12
MIAMI	5	22
MITCHELL	3	8
MONTGOMERY	6	41
MORRIS	3	5
MORTON	2	8
NEMAHA	5	9
NEOSHO	6	11
NESS	2	19
NORTON	1	10
OSAGE	5	12
OSBORNE	3	9
OTTAWA	3	6
PAWNEE	2	2
PHILLIPS	1	27
POTTAWATOMIE	5	11
PRATT	4	9
RAWLINS	1	10
RENO	4	45
REPUBLIC	3	8
RICE	4	7
RILEY	3	32
ROOKS	1	10
RUSH	2	8
RUSSELL	3	8
SALINE	3	32
SCOTT	2	21
SEDGWICK	4	217
SEWARD	2	12
SHAWNEE	5	109
SHERIDAN	1	8

Table C-1 Distribution of Canisters per County for Kansas (Continued)

COUNTY	REGION	# CANISTERS
SHERMAN	1	8
SMITH	3	7
STAFFORD	4	7
STANTON	2	4
STEVENS	2	3
SUMNER	4	10
THOMAS	1	14
TREGO	1	14
WABAUNSEE	5	7
WALLACE	1	3
WASHINGTON	3	7
WICHITA	2	3
WILSON	6	15
WOODSON	6	17
WYANDOTTE	5	110

Table C-1 Distribution of Canisters per County for Kentucky

COUNTY	REGION	# CANISTERS
ADAIR	5	1
ALLEN	2	4
ANDERSON	4	2
BALLARD	1	8
BARREN	2	7
BATH	6	7
BELL	5	4
BOONE	3	13
BOURBON	4	10
BOYD	6	19
BOYLE	4	2
BRACKEN	4	4
BREATHITT	6	1
BRECKINRIDGE	2	4
BULLITT	2	11
BUTLER	1	14
CALDWELL	1	5
CALLOWAY	1	8
CAMPBELL	3	25
CARLISLE	1	4
CARROLL	3	1
CARTER	6	3
CASEY	5	7
CHRISTIAN	1	16
CLARK	4	4
CLAY	5	1
CLINTON	5	3
CRITTENDEN	1	6
CUMBERLAND	5	3
DAVIESS	2	20
EDMONSON	2	5
ELLIOTT	6	2
ESTILL	5	4
FAYETTE	4	52
FLEMING	6	2
FLOYD	6	5
FRANKLIN	4	17
FULTON	1	1
GALLATIN	3	1
GARRARD	5	5
GRANT	3	1
GRAVES	1	12
GRAYSON	2	6
GREEN	5	2
GREENUP	6	12

Table C-1 Distribution of Canisters per County for Kentucky (Continued)

COUNTY	REGION	# CANISTERS
HANCOCK	2	1
HARDIN	2	26
HARLAN	5	1
HARRISON	4	5
HART	2	9
HENDERSON	1	8
HENRY	3	3
HICKMAN	1	3
HOPKINS	1	8
JACKSON	5	4
JEFFERSON	3	111
JESSAMINE	5	11
JOHNSON	6	2
KENTON	3	40
KNOTT	6	2
KNOX	5	4
LARUE	2	3
LAUREL	5	5
LAWRENCE	6	4
LEE	5	4
LESLIE	5	4
LETCHER	6	5
LEWIS	6	2
LINCOLN	0	0
LIVINGSTON	1	3
LOGAN	1	8
LYON	1	3
MADISON	4	5
MAGOFFIN	6	1
MARION	2	3
MARSHALL	1	9
MARTIN	0	0
MASON	6	8
MCCRACKEN	1	15
MCCREARY	5	6
MCLEAN	1	5
MEADE	2	4
MENIFEE	6	2
MERCER	4	10
METCALFE	5	5
MONROE	5	3
MONTGOMERY	4	5
MORGAN	6	7
MUHLENBERG	1	6
NELSON	2	13

Table C-1 Distribution of Canisters per County for Kentucky (Continued)

COUNTY	REGION	# CANISTERS
NICHOLAS	4	5
OHIO	1	3
OLDHAM	3	2
OWEN	3	1
OWSLEY	0	0
PENDLETON	3	8
PERRY	6	4
PIKE	6	9
POWELL	6	4
PULASKI	5	8
ROBERTSON	4	2
ROCKCASTLE	5	4
ROWAN	6	3
RUSSELL	5	2
SCOTT	4	8
SHELBY	4	6
SIMPSON	2	8
SPENCER	2	1
TAYLOR	5	4
TODD	1	6
TRIGG	1	8
TRIMBLE	3	1
UNION	1	6
WARREN	2	25
WASHINGTON	2	3
WAYNE	5	1
WEBSTER	1	3
WHITLEY	5	6
WOLFE	6	2
WOODFORD	4	6

Table C-1 Distribution of Canisters per County for Michigan

COUNTY	REGION	# CANISTERS
ALCONA	4	4
ALGER	4	11
ALLEGAN	4	8
ALPENA	4	18
ANTRIM	4	8
ARENAC	4	3
BARAGA	4	22
BARRY	4	14
BAY	4	18
BENZIE	4	3
BERRIEN	4	44
BRANCH	1	9
CALHOUN	1	31
CASS	0	0
CHARLEVOIX	4	12
CHEBOYGAN	4	14
CHIPPEWA	4	8
CLARE	4	3
CLINTON	1	18
CRAWFORD	4	1
DELTA	4	41
DICKINSON	1	77
EATON	1	21
EMMET	4	4
GENESEE	4	42
GLADWIN	4	4
GOGEBIC	4	11
GRAND TRAVERSE	4	21
GRATIOT	4	7
HILLSDALE	2	12
HOUGHTON	4	18
HURON	4	15
INGHAM	1	42
IONIA	4	10
IOSCO	4	9
IRON	1	38
ISABELLA	4	12
JACKSON	1	23
KALAMAZOO	1	55
KALKASKA	4	5
KENT	4	73
KEWEENAW	4	6
LAKE	0	0
LAPEER	4	13
LEELANAU	4	6

Table C-1 Distribution of Canisters per County for Michigan (Continued)

COUNTY	REGION	# CANISTERS
LENAWEE	2	37
LIVINGSTON	1	21
LUCE	4	7
MACKINAC	4	6
MACOMB	4	92
MANISTEE	4	6
MARQUETTE	3	139
MASON	4	6
MECOSTA	4	5
MENOMINEE	4	22
MIDLAND	4	16
MISSAUKEE	4	7
MONROE	4	20
MONTCALM	4	10
MONTMORENCY	4	8
MUSKEGON	4	34
NEWAYGO	0	0
OAKLAND	1	158
OCEANA	0	0
OGEMAW	4	7
ONTONAGON	4	24
OSCEOLA	4	9
OSCODA	4	4
OTSEGO	4	15
OTTAWA	4	36
PRESQUE ISLE	4	12
ROSCOMMON	4	9
SAGINAW	4	41
SANILAC	4	21
SCHOOLCRAFT	4	8
SHIAWASSEE	4	18
ST. CLAIR	4	60
ST. JOSEPH	4	13
TUSCOLA	4	17
VAN BUREN	4	15
WASHTENAW	2	93
WAYNE	4	177
WEXFORD	4	2

Table C-1 Distribution of Canisters per County for Rhode Island

COUNTY	REGION	# CANISTERS
BRISTOL	1	22
KENT	1	80
NEWPORT	1	37
PROVIDENCE	1	185
WASHINGTON	1	52

Table C-1 Distribution of Canisters per County for Tennessee

COUNTY	REGION	# CANISTERS
ANDERSON	10	35
BEDFORD	3	10
BENTON	2	2
BLEDSOE	6	1
BLOUNT	10	40
BRADLEY	8	35
CAMPBELL	10	8
CANNON	5	7
CARROLL	2	9
CARTER	11	30
CHEATHAM	3	15
CHESTER	2	1
CLAIBORNE	10	10
CLAY	5	9
COCKE	10	4
COFFEE	3	30
CROCKETT	2	6
CUMBERLAND	6	5
DAVIDSON	4	245
DE KALB	5	8
DECATUR	2	3
DICKSON	3	12
DYER	2	6
FAYETTE	2	2
FENTRESS	6	4
FRANKLIN	6	26
GIBSON	2	13
GILES	3	14
GRAINGER	10	3
GREENE	11	20
GRUNDY	6	3
HAMBLEN	10	22
HAMILTON	7	120
HANCOCK	11	4
HARDEMAN	2	5
HARDIN	2	6
HAWKINS	11	18
HAYWOOD	2	4
HENDERSON	2	9
HENRY	3	12
HICKMAN	3	12
HOUSTON	3	2
HUMPHREYS	2	6
JACKSON	5	11
JEFFERSON	10	13

Table C-1 Distribution of Canisters per County for Tennessee (Continued)

COUNTY	REGION	# CANISTERS
JOHNSON	11	6
KNOX	9	131
LAKE	2	2
LAUDERDALE	2	8
LAWRENCE	2	6
LEWIS	0	0
LINCOLN	3	16
LOUDON	8	13
MACON	5	10
MADISON	2	15
MARION	6	5
MARSHALL	3	5
MAURY	3	39
MCMINN	8	18
MCNAIRY	2	5
MEIGS	8	3
MONROE	8	9
MONTGOMERY	3	18
MOORE	3	5
MORGAN	6	5
OBION	2	6
OVERTON	6	5
PERRY	2	1
PICKETT	0	0
POLK	8	8
PUTNAM	6	27
RHEA	8	13
ROANE	8	22
ROBERTSON	3	12
RUTHERFORD	5	23
SCOTT	6	5
SEQUATCHIE	6	2
SEVIER	10	16
SHELBY	1	144
SMITH	5	2
STEWART	3	5
SULLIVAN	11	73
SUMNER	5	70
TIPTON	2	6
TROUSDALE	5	3
UNICOI	11	14
UNION	10	3
VAN BUREN	0	0
WARREN	6	10
WASHINGTON	11	35

Table C-1 Distribution of Canisters per County for Tennessee (Continued)

COUNTY	REGION	# CANISTERS
WAYNE	2	4
WEAKLEY	2	7
WHITE	6	5
WILLIAMSON	3	56
WILSON	5	17

Table C-1 Distribution of Canisters per County for Wisconsin

COUNTY	REGION	# CANISTERS
ADAMS	4	2
ASHLAND	10	8
BARRON	5	14
BAYFIELD	10	8
BROWN	8	28
BUFFALO	10	8
BURNETT	10	9
CALUMET	8	3
CHIPPEWA	5	18
CLARK	5	4
COLUMBIA	4	8
CRAWFORD	9	5
DANE	4	87
DODGE	9	12
DOOR	8	8
DOUGLAS	10	9
DUNN	5	13
EAU CLAIRE	5	20
FLORENCE	3	13
FOND DU LAC	9	22
FOREST	10	6
GRANT	9	10
GREEN	9	6
GREEN LAKE	4	2
IOWA	9	1
IRON	10	5
JACKSON	5	2
JEFFERSON	9	15
JUNEAU	4	2
KENOSHA	7	21
KEWAUNEE	8	5
LA CROSSE	5	26
LAFAYETTE	9	4
LANGLADE	2	19
LINCOLN	10	4
MANITOWOC	8	18
MARATHON	1	71
MARINETTE	3	13
MARQUETTE	4	4
MENOMINEE	2	2
MILWAUKEE	6	124
MONROE	5	7
OCONTO	2	30
ONEIDA	10	8
OUTAGAMIE	9	23

Table C-1 Distribution of Canisters per County for Wisconsin (Continued)

COUNTY	REGION	# CANISTERS
OZAUKEE	8	12
PEPIN	10	4
PIERCE	10	6
POLK	10	9
PORTAGE	1	30
PRICE	10	10
RACINE	7	31
RICHLAND	9	3
ROCK	9	18
RUSK	10	4
SAUK	4	7
SAWYER	3	34
SHAWANO	2	30
SHEBOYGAN	8	20
ST. CROIX	10	10
TAYLOR	10	11
TREMPEALEAU	5	8
VERNON	9	2
VILAS	3	45
WALWORTH	7	8
WASHBURN	5	1
WASHINGTON	8	16
WAUKESHA	7	58
WAUPACA	2	39
WAUSHARA	4	7
WINNEBAGO	9	25
WOOD	4	16

Table C-1 Distribution of Canisters per County for Wyoming

COUNTY	REGION	# CANISTERS
ALBANY	4	52
BIG HORN	1	26
CAMPBELL	1	76
CARBON	2	48
CONVERSE	4	28
CROOK	2	20
FREMONT	3	50
GOSHEN	4	28
HOT SPRINGS	2	5
JOHNSON	2	25
LARAMIE	2	67
LINCOLN	5	35
NATRONA	1	31
NIOBRARA	5	15
PARK	1	41
PLATTE	2	14
SHERIDAN	5	69
SUBLETTE	1	21
SWEETWATER	3	67
TETON	2	18
UINTA	1	7
WASHAKIE	2	18
WESTON	5	16

APPENDIX D

Regional Radon Coordinators and Sources of Information Concerning Other State-Wide Radon Studies

Regional Radon Coordinators

EPA REGION	REGIONAL OFFICE	CONTACT
1	U.S. Environmental Protection Agency John F. Kennedy Federal Building Room 2311 Boston, MA 02203	Mona Haywood (617) 565-9402
2	U.S. Environmental Protection Agency 26 Federal Plaza Room 1137-L New York, NY 10278	Lorainne Koehler (212) 264-0546
3	U.S. Environmental Protection Agency (3AM12) 841 Chestnut Street Philadelphia, PA 19107	Lewis Felleisen (215) 597-8326
4	U.S. Environmental Protection Agency 345 Courtland Street, NE Atlanta, GA 30365	Paul Wagner (404) 347-3907
5	U.S. Environmental Protection Agency Mail Code (AT-18J) 77 West Jackson Blvd. Chicago, IL 60604	Julie Beckman (312) 886-6063
6	U.S. Environmental Protection Agency Air Enforcement Branch (6T-E) 1445 Ross Avenue Dallas, TX 75202	Michael Miller (214) 655-7550
7	U.S. Environmental Protection Agency 726 Minnesota Avenue Kansas City, KS 66101	Bob Hunt (913) 551-7611
8	U.S. Environmental Protection Agency (8HWM-RP) Suite 500 999 18th Street Denver, CO 80202	Milton W. Lammering (303) 293-1440
9	U.S. Environmental Protection Agency (A1-1) 75 Hawthorne Street San Francisco, CA 94105	Louise Hill (415) 744-1046
10	U.S. Environmental Protection Agency (AT-082) 1200 Sixth Avenue Seattle, WA 98101	Misha Vakoc (206) 553-7299

Sources of Information Concerning Other State-Wide Radon Studies		
STATE	AGENCY	CONTACT
New Jersey	Department of Environmental Protection 729 Alexander Road Princeton, NJ 08540	Robert Stern (800) 648-0394 (609) 987-6402
New York	State Health Department Bureau of Environmental Radiation Protection Corning Tower Albany, NY 12237	Laurence Keefe (800) 458-1158 (518) 458-6450
North Carolina	Department of Human Resources Radiation Protection Section 701 Barbour Drive Raleigh, NC 27603-2008	Dr. Felix Fong (919) 733-4283
Idaho	Department of Health and Welfare Bureau of Preventive Medicine 450 West State Street Boise, ID 83720	Janne Mitten (208) 334-5927
Florida	Department of Health and Rehabilitative Services 1317 Winewood Boulevard Tallahassee, FL 32399-0700	N. Michael Gilly (800) 543-8279 (904) 488-1525
South Carolina	Department of Health and Environmental Control Bureau of Radiological Health 2600 Bull Street Colombia, SC 29201	Nolan Bivens (803) 734-4700
Oregon	Department of Human Services Health Division 1400 SW 5th Avenue Portland, OR 97201	Ray Paris (503) 229-5797
Washington	Department of Health Office of Radiation Protection Airdustrial Building 5, LE-13 Olympia, WA 98504	Robert Mooney (206) 586-3303

STATE	AGENCY	CONTACT
Montana	Department of Health and Environmental Sciences Cogswell Building Helena, MT 59620	Adrian Howe (406) 444-3671
New Hampshire	Division of Public Health Serv. Bureau of Radiological Health 6 Hazen Drive Concord, NH 03301	Joy Hanington (603) 271-4674
Virginia	Department of Health Bureau of Radiological Health 109 Governor Street Richmond, VA 23219	Leslie Foldesi (800) 468-0138 (804) 786-5932
Nevada	Department of Human Resources Radiological Health Section 505 East King Street, Rm. 203 Carson City, NV 89710	Stan Marshall (702) 885-5394
Louisiana	Louisiana Nuclear Energy Division Department of Environmental Qual. P.O. Box 14690 Baton Rouge, LA 70898	Jay Mason (504) 925-4518